AMENDMENTS TO THE DRAWINGS:

Eighteen replacement sheets of drawings containing FIGS. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12A-12D, 13A, 13B, and 14 are attached to this paper and include changes that are discussed below in the remarks.

The twelve replacement sheets containing FIGS. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12A-12D, 13A, 13B, and 14 replace the twelve original sheets of drawings containing FIGS. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12A-12D, 13A, 13B, and 14 included in the application papers filed on February 28, 2005.

REMARKS

In accordance with the foregoing, the abstract, the specification, FIGS. 3, 4, 6, 7, 9, 10, 12A-12D, 13A, and 13B, and claims 1-14 have been amended, and new claims 15-17 have been added. Claims 1-17 are pending, with claims 1 and 9 being independent. No new matter is presented in this Amendment.

Substitute Specification

Pursuant to 37 CFR 1.125(b) and MPEP 608.01(q), the original specification has been replaced by the attached substitute specification to correct errors in the original specification and improve its form.

Pursuant to 37 CFR 1.125(c) and MPEP 608.01(q), the substitute specification is in clean form without markings and is accompanied by a marked-up copy of the substitute specification showing all of the changes relative to the original specification, with added text being shown by underlining and deleted text being shown by ~~strikethrough~~.

Pursuant to 37 CFR 1.125(b) and MPEP 608.01(q), the substitute specification includes no new matter.

It is respectfully requested that the substitute specification be entered, and that the Examiner confirm that this has been done in the next Office Action.

Drawing Amendments

FIGS. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12A-12D, 13A, 13B, and 14 have been amended to change the figure legends from the form "FIGURE n" to the form "FIG. n" and to move the figure legends from below the figure to above the figure.

FIG. 3 has been amended to change reference numeral 17 to ECG RA, and to add reference numeral 100.

FIG. 4 has been amended to delete the line between blocks 16 and 17, to change the label "ECG MONITOR" on block 17 to "ECG ELECTRODES," to change reference numeral 17

to ECG LL, ECG RA, to change reference numeral 61 to 62, and to change reference numeral 62 to 61.

FIG. 6 has been amended to change reference numeral R16 to R51 to avoid conflict with reference numeral R16 in FIG. 7

FIG. 7 has been amended to change reference label ECGLL at the input to resistor R16 to ECG LL, to change reference label ECGLL at the input to resistor R27 to ECG RA, and to add reference numeral 30.

FIG. 9 has been amended to change the label "OPERATING" on block S17 to "COMPARING AND DETERMINING," and to change the label "OUTPUTTING OPERATION RESULT" on block S18 to "DISPLAYING."

FIG. 10 has been amended to change the word "OPERATING" in the label on blocks S24, S26, S27, S28, and S29 to "DETERMINING," and to change the word "OOPERATING" in the label on block S25 to "DETERMINING."

FIG. 12A has been amended to change the label "Delta t" at the top of the graph to "ΔT," to change the label "Time(sec)" on the vertical axis to "ΔT (sec)," and to change the label "Blood pressure(mmHG)" on the horizontal axis to "Systolic Blood Pressure (mm Hg)."

FIG. 12B has been amended to change the label "Blood pressure(mmHG)" on the horizontal axis to "Systolic Blood Pressure (mm Hg)."

FIG. 12C has been amended to change the label "Blood pressure(mmHG)" on the horizontal axis to "Systolic Blood Pressure (mm Hg)."

FIG. 12D has been amended to change the label "Voltage(V)" on the vertical axis to "Max (V)," and to change the label "Blood pressure(mmHG)" on the horizontal axis to "Systolic Blood Pressure (mm Hg)."

FIG. 13A has been amended to change the label "Delta T" at the top of the graph to "ΔT," to change the label "delta T(sec)" on the vertical axis to "ΔT (sec)," and to change the label "blood pressure(mmHG)" on the horizontal axis to "Diastolic Blood Pressure (mm Hg)."

FIG. 13B has been amended to change the label "Blood pressure(mmHG)" on the horizontal axis to "Diastolic Blood Pressure (mm Hg)."

The change of the label on the horizontal axis in FIGS. 12A-12D to read "Systolic Blood Pressure (mm Hg) is supported at least by page 8, lines 16-17, of the specification as originally filed.

The change of the label on the horizontal axis in FIGS. 13A and 13B to read "Diastolic Blood Pressure" is supported at least by page 8, lines 18-19, of the specification as originally filed.

Drawing Objections

The drawings were objected to as failing to comply with 37 CFR 1.84(p)(4) "because reference character '22' has been used to designate both a low pass filter (p. 13, line 12 of the specification) and an amplifier (p. 12, lines 16-17 of the specification)."

There is only one element in the drawings that is designated by reference number 22 (see FIG. 7), and accordingly it is submitted that the drawings do in fact comply with 37 CFR 1.84(p)(4). However, that one element 22 has three different names in the specification as originally filed, i.e., "pulse wave signal amplifying means 22" (page 12, lines 16-17), "first low-pass filter 22" (page 13, line 12, and page 14, line 5), and "pulse wave amplifying means 22" (page 23, lines 3-4), which apparently misled the Examiner into thinking that reference numeral 22 was being used to designate two different elements in the drawings. As can be seen from page 13, lines 11-19, of the specification as originally filed, element 22 in FIG. 7 filters and amplifies the output signal of first impedance matching means 21 in FIG. 7. Accordingly, the specification has been amended to use only the name "first low-pass filter 22" for element 22 in FIG. 7.

For at least the foregoing reasons, it is respectfully requested that the objection to the drawings as failing to comply with 37 CFR 1.84(p)(4) be withdrawn.

Claim Objections

Claims 1, 4, 7, and 9 were objected to because of the informalities identified by the Examiner on pages 2-3 of the Office Action of August 1, 2006. Accordingly, claims 1, 4, 7, and 9 have been amended to eliminate the informalities identified by the Examiner.

For at least the foregoing reasons, it is respectfully requested that the objection to claims 1, 4, 7, and 9 be withdrawn.

Allowable Subject Matter

The applicant acknowledges the Examiner's indication that claims 4, 7, and 8 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Claim Rejections Under 35 USC 112

Rejection 1

Claims 9-14 were rejected under 35 USC 112, first paragraph, as failing to comply with the enablement requirement because the Examiner is of the opinion that the application fails to set forth clearly how the "converting AC signals of the pulse wave and the electrocardiogram into DC signals after the amplifying and filtering steps" recited in independent claim 9 as originally filed occurs. The Examiner states that "[i]t appears that the applicant may have instead intended to claim 'converting analog signals of the pulse wave and the electrocardiogram into digital signals after the amplifying and filtering steps.'"

The applicant did in fact intend to claim converting analog signals into digital signals as suspected by the Examiner, and accordingly claim 9 has been amended to recite "converting the processed analog pulse wave signal and the processed analog electrocardiogram signal into a digital pulse wave signal and a digital electrocardiogram signal," and corresponding changes have been made to the specification, the abstract, and claim 1.

For at least the foregoing reasons, it is respectfully requested that the rejection of claims 9-14 under 35 USC 112, first paragraph, be withdrawn.

Rejection 2

Claims 1-8 were rejected under 35 USC 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the applicant regards as the invention.

With respect to the feature "an electrocardiogram monitor for measuring a systolic blood pressure and a diastolic blood pressure and converting the measured results into electric signals" recited in independent claim 1 as originally filed, the Examiner states that "it appears from the applicant's specification that the electrocardiogram monitor obtains electrical signals representative of the subject's ECG, rather than measuring a systolic blood pressure and a diastolic blood pressure, as claimed." The Examiner's understanding is correct. Although element 17 in FIG. 3 is identified as "an ECG monitor" in the specification as originally filed, it is readily apparent from FIGS. 1 and 3 that element 17 is in fact an ECG electrode fixed to a right arm of a subject, and is the second ECG electrode ECGLL shown in FIG. 7 as originally filed (the ECG electrode that is connected to the resistor R27) which should have been labeled ECGRA as can be seen from page 9, lines 19-20; page 14, lines 18-19; and page 22, lines 20-21, of the specification as originally filed.

The first ECG electrode ECGLL shown in FIG. 7 as originally filed (the ECG electrode that is connected to resistor R16) and the second ECG electrode ECGRA are connected to the connection ports 13 of the automatic blood pressure instrument 100 shown in FIG. 1 as would be understood by one of ordinary skill in the art from the following passage that appears on page 9, lines 17-20, of the specification as originally filed:

> Subsequently, the ECG monitor 17 is connected to the ECG connection ports 13. Then, a first electrode (ECG LL, FIG. 7) is fixed to a left foot of the subject, while a second electrode (ECG RA, FIG. 7) is attached to a right foot of the subject.

and from the following passage that appears on page 22, lines 18-21, of the specification as originally filed:

> The ECG monitor 17 is connected to the ECG connection ports 13 provided on one side of the automatic blood pressure measuring instrument 100. The first electrode ECG LL of the ECG monitor 17 is fixed to the left ankle of the subject, while the second electrode ECG RA is fixed to the right arm.

Accordingly, claim 1 has been amended to recite "electrocardiogram electrodes for detecting an electrocardiogram signal of the subject," and corresponding changes have been made the specification, abstract, claim 9, and the drawings, it being noted that the term "ECG monitor 17" has been changed to "second ECG electrode ECGRA."

With respect to the feature "an A/D converting section for converting the AC signals, which are applied from both the pulse wave signal processing section and the electrocardiogram signal processing section, into DC signals" recited in claim 1 as originally filed, the Examiner states that "[a]n 'A/D' converter refers to a device that converts analog signals into digital signals, not one that converts alternating current (AC) into direct current (DC)," and that "[i]t is unclear form [sic] the claim language whether the applicant intended to claim an A/D converter or an AC to DC adapter." The applicants did in fact intend to claim an A/D converting section that converts analog signals to digital signals, and accordingly claim 1 has been amended to recite "an A/D converting section for converting the processed analog pulse wave signal and the processed analog electrocardiogram signal into a digital pulse wave signal and a digital electrocardiogram signal," and corresponding changes have been made to the specification, the abstract, and claim 9.

For at least the foregoing reasons, it is respectfully requested that the rejection of claims 1-8 under 35 USC 112, second paragraph, be withdrawn.

Claim Rejections Under 35 USC 103

Rejection 1

Claims 1, 2, and 5 were rejected under 35 USC 103(a) as being unpatentable over Yanagi et al. (Yanagi) (U.S. Patent No. 5,873,834) in view of Baba et al. (Baba) (U.S. Patent No. 5,735,799), although only claim 1 is listed in the statement of this rejection on page 6 of the Office Action of August 1, 2006. This rejection is respectfully traversed insofar as it may be deemed to be applicable to claims 1, 2, and 5 in their present form.

It is submitted that Yanagi and Baba do not disclose or suggest "a controlling section for comparing and analyzing the digital pulse wave signal and the digital electrocardiogram signal to determine parameters comprising a transition time parameter, an integral parameter, an area parameter, and a maximum amplitude parameter, and determining the blood pressure of the

subject based on the transition time parameter, the integral parameter, the area parameter, and the maximum amplitude parameter" as now recited in independent claim 1. It is noted that these features are similar to features that were recited in claim 10 as originally filed which was not rejected over the prior art, but was only rejected under 35 USC 112, first paragraph. It is presumed that this indicates that the Examiner considers claim 10 as originally filed to be patentable over Yanagi and Baba.

In contrast, FIGS. 4-7 of Yanagi disclose relationships between systolic and diastolic blood pressures and a pulse wave transit time (PTT) (see FIG. 10 of Yanagi), a cardiac pulse rate (HR), and a second-derivative pulse wave height (Hv or b/a) (see FIG. 10 of Yanagi). FIG. 8 of Yanagi discloses a method determining a blood pressure of a subject based on the pulse wave transit time (PTT). FIG. 16 of Yanagi discloses a method of determining a blood pressure of a subject based on the pulse wave transit time (PTT) and the second-derivative pulse wave height (Hv or b/a). Column 6, lines 18-22, of Yanagi discloses that other types of physiological data "such as heart rate, baseline oscillation period, rise time of pulsewave, or primary derivative pulsewave of the photoelectric waveform" can be used in determining a blood pressure of a subject.

For at least the foregoing reasons, it is respectfully requested that the rejection of claims 1, 2, and 5 (i.e., claim 1 and claims 2 and 5 depending therefrom) under 35 USC 103(a) as being unpatentable over Yanagi in view of Baba be withdrawn.

Rejection 2

Claim 3 was rejected under 35 USC 103(a) as being unpatentable over Yanagi in view of Baba as applied to claims 1, 2, and 5, and further in view of Stephens (U.S. Patent No. 4,442,845) and Royal et al. (Royal) (U.S. Patent 3,903,873). This rejection is respectfully traversed.

Notwithstanding the position taken by the Examiner, it is submitted that claim 3 which depends from claim 1 is patentable over Yanagi, Baba, Stephens, and Royal for at least the same reasons discussed above that claim 1 is patentable over Yanagi and Baba. Accordingly, it is respectfully requested that the rejection of claim 3 under 35 USC 103(a) as being

unpatentable over Yanagi in view of Baba as applied to claims 1, 2, and 5, and further in view of Stephens and Royal be withdrawn.

Rejection 3

Claim 6 was rejected under 35 USC 103(a) as being unpatentable over Yanagi in view of Baba as applied to claims 1, 2, and 5, and further in view of Silvian (U.S. Patent No. 4,742,831). This rejection is respectfully traversed.

Notwithstanding the position taken by the Examiner, it is submitted that claim 6 which depends indirectly from claim 1 is patentable over Yanagi, Baba, and Silvian for at least the same reasons discussed above that claim 1 is patentable over Yanagi and Baba. Accordingly, it is respectfully requested that the rejection of claim 6 under 35 USC 103(a) as being unpatentable over Yanagi in view of Baba as applied to claims 1, 2, and 5, and further in view of Silvian be withdrawn.

Allowability of Claims 9-14

Claims 9-14 were not rejected over the prior art, but were only rejected under 35 USC 112, first paragraph. This rejection is considered to have been overcome as discussed above.

Since the Examiner did not reject any of claims 9-14 over Yanagi, Baba, Stephens, Royal, and Silvian relied on by the Examiner in the rejections of claims 1-3, 5, and 6 under 35 USC 103(a), it is presumed that this indicates that the Examiner considers claims 9-14 to be patentable over these references. In any event, it is submitted that Yanagi, Baba, Stephens, Royal, and Silvian do not disclose or suggest "comparing and analyzing the digital pulse wave signal and the digital electrocardiogram signal to determine parameters comprising a transition time parameter, an integral parameter, an area parameter, and a maximum amplitude parameter" and "determining the blood pressure of the subject based on the transition time parameter, the integral parameter, the area parameter, and the maximum amplitude parameter" as now recited in independent claim 9. It is noted that these features are similar to features that were recited in claim 10 as originally filed which was not rejected over the prior art, but was only rejected under 35 USC 112, first paragraph. It is presumed that this indicates that the Examiner

considers claim 10 as originally filed to be patentable over Yanagi, Baba, Stephens, Royal, and Silvian.

For at least the foregoing reasons, it is submitted that claims 9-14 (i.e. claim 9 and claims 10-14 depending therefrom) are patentable over Yanagi, Baba, Stephens, Royal, and Silvian, and an indication to that effect is respectfully requested.

Allowability of New Claims 15-17

It is submitted that Yanagi, Baba, Stephens, Royal, and Silvian do not disclose or suggest the features "wherein the controlling section determines a systolic blood pressure of the subject based on the transition time parameter, the integral parameter, the area parameter, and the maximum amplitude parameter" and "wherein the controlling section determines a diastolic blood pressure of the subject based on the transition time parameter and the area parameter but not the integral parameter or the maximum amplitude parameter" recited in new dependent claim 15.

It is submitted that Yanagi, Baba, Stephens, Royal, and Silvian do not disclose or suggest the feature "wherein the controlling section determines the systolic blood pressure of the subject using the following systolic blood pressure determination algorithm:

$$P = 919.121 \cdot Ar + 17.157 \cdot Max - 98.26 \cdot Int + 161.736 \cdot \Delta T$$

where Ar is the area parameter, Max is the maximum amplitude parameter, Int is the integral parameter, and ΔT is the transition time parameter" recited in new dependent claim 16.

It is submitted that Yanagi, Baba, Stephens, Royal, and Silvian do not disclose or suggest the feature "wherein the controlling section determines the diastolic blood pressure of the subject using the following diastolic blood pressure determination algorithm:

$$P = 146.161 - 78.903 \cdot \Delta T - 442.904 \cdot Ar$$

where ΔT is the transition time parameter and Ar is the area parameter" recited in new depending claim 16

It is submitted that Yanagi, Baba, Stephens, Royal, and Silvian do not disclose or suggest the feature "wherein the determining of the systolic blood pressure of the subject

comprises determining the systolic blood pressure of the subject using the following systolic blood pressure determination algorithm:

$$P = 919.121 \cdot Ar + 17.157 \cdot Max - 98.26 \cdot Int + 161.736 \cdot \Delta T$$

where Ar is the area parameter, Max is the maximum amplitude parameter, Int is the integral parameter, and ΔT is the transition time parameter" recited in new dependent claim 17.

It is submitted that Yanagi, Baba, Stephens, Royal, and Silvian do not disclose or suggest the feature "wherein the determining of the diastolic blood pressure of the subject comprises determining the diastolic blood pressure of the subject using the following diastolic blood pressure determination algorithm:

$$P = 146.161 - 78.903 \cdot \Delta T - 442.904 \cdot Ar$$

where ΔT is the transition time parameter and Ar is the area parameter" now recited in new dependent claim 17.

For at least the foregoing reasons, it is submitted that new claims 15-17 are patentable over Yanagi, Baba, Stephens, Royal, and Silvian, and an indication to that effect is respectfully requested.

Conclusion

There being no further outstanding objections or rejections, it is submitted that the application is in condition for allowance. An early action to that effect is courteously solicited.

Finally, if there are any formal matters remaining after this response, the Examiner is requested to telephone the undersigned to attend to these matters.

If there are any additional fees associated with the filing of this paper, please charge the same to our Deposit Account No. 503333.

Respectfully submitted,

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Date: 11/01/06

By: _____

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Attachments

TITLE OF THE INVENTION

AUTOMATIC BLOOD PRESSURE MEASURING INSTRUMENT AND METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is the U.S. National Stage of International Application No. PCT/KR2003/001772 filed on August 30, 2003, and claims the benefit of Korean Application No. 2002-52213 filed on August 31, 2002, in the Korean Intellectual Property Office.

BACKGROUND OF THE INVENTION

~~Technical~~ 1. Field of the Invention

[0002] ~~The present~~ An aspect of invention relates to a blood pressure measuring instrument, and more particularly, to an automatic blood pressure measuring instrument and method designed to obtain a pulse wave signal and an electrocardiogram (ECG) ~~signals~~ signal from a pressure sensor and ~~an~~ ECG ~~monitor~~ electrodes, to analyze a correlation between both signals, to ~~operate~~ determine a maximum blood pressure and a minimum blood pressure based on the analyzed data, and to output the ~~operated~~ determined result to a display.

~~Background~~ 2. Description of the Related Art

[0003] As the number of the home health aged has been increased due to the general aging of society, a gradually increasing attention has been drawn to welfare and care for the aged. Thus, the approach of an elderly health care has begun to occur in a new scheme at various angles, and a concentrated attention has been paid to a blood pressure measurement functioning as the basis of health check-up.

[0004] Measurement of a blood pressure, as one of current generalized clinical tests, is carried out while a doctor performs an examination or a particular surgical operation. Further, values of blood pressure, which are measured in respective ventricle and atrium of the heart or in a peripheral vascular system, function as a basis of health check-up helpful to enable the doctor to understand an integrated function between vascular and cardiac systems.

[0005] A blood pressure refers to one generated when blood flowing a blood vessel acts on a wall of the blood vessel, and is determined by a quantity of the blood and a resistance of the blood vessel, such as elasticity, expansion, contraction and so on. Measurement of the blood pressure allows for estimation of a function of the heart or the blood vessel. To be more specific, while the heart is contracted, the blood is driven to circulate around the whole body. The pressure of the driven blood, or the maximum blood pressure, represents a contractile force of the heart. The minimum blood pressure when the heart is expanded can be considered as an index indicating how smoothly the blood circulates through the blood vessel.

[0006] The human blood vessel consists of an artery through which blood exits from the heart toward the whole body, a vein through which blood enters from the whole body toward the heart, and a capillary vessel interconnecting between the artery and the vein. In general, a pressure in the artery, i.e., an arterial blood pressure, is called a "blood pressure." This blood pressure is very different according to size and position of the blood vessel, and is sequentially lowered in the order of an aorta, an artery, an arteriole, a capillary vessel, a veinlet, a vein and a hollow. For this reason, the blood pressure is named for the name of the blood vessel, for example, as an aortic blood pressure, an arterial blood pressure, an arteriole blood pressure and so forth. The arterial blood pressure maintained by heartbeats is one of fundamental, usual clinical symptoms estimating a function between the vascular and cardiac systems, and a factor taking part in perfusion of the entire tissues, or particularly having an important influence on a cerebral blood flow and a coronary blood flow.

[0007] As existing blood pressure measuring methods, there are an invasive one and non-invasive one. The invasive method inserts a catheter directly into an artery to measure the blood pressure. However, it requires much trouble and heavy cost in measuring the blood pressure, and has various disadvantages, such as circulatory problem of the blood, infection, blood clot and so on, in the course of inserting the catheter into the artery. For these reasons, the invasive method has been used in an extremely limited range. By contrast, the non-invasive method mainly makes use of a cuff. However, the non-invasive method is not only very inaccurate, but also is responsible for a tissular trauma. Further, it is impossible to apply to infants or low blood pressure patients, and above all to perform continuous monitoring. Additionally, an electronic hemadynamometer, which has been frequently used at the present

time, shows a tendency of its accuracy to be significantly lowered when the blood pressure is less than 70 mmHg.

[0008] To measure the blood pressure, there have been many attempts to make use of a pulse wave velocity. Further, there has been devised a blood pressure estimating method using the pulse wave velocity or a pulse arrival time by many persons. However, in the case of using only the pulse wave velocity or the pulse arrival time, it is impossible to ensure accomplishment of reliable blood pressure monitoring

~~Disclosure of Invention~~

SUMMARY OF THE INVENTION

[0009] ~~It is, therefore, an object~~ An aspect of the ~~present~~ invention is to provide an automatic blood pressure measuring instrument and method~~,~~ capable of measuring a blood pressure even though infants, low blood pressure patients, intensive care patients, etc.~~,~~ ~~can not~~ cannot be measured by an existing blood pressure measuring instrument, and capable of expanding an application range as a vascular automatic diagnosis device using a pulse wave signal, including ~~simply~~ a simple blood pressure measurement.

[0010] ~~Further, it is another object~~ Another aspect of the ~~present~~ invention is to provide an automatic blood pressure measuring instrument and method~~,~~ capable not only of continuously measuring systolic and diastolic blood pressures for a short and long time, but also of monitoring for a long time by a non-invasive method.

[0011] In ~~order to accomplish these objects, there is provided~~ accordance with an aspect of the invention, an automatic blood pressure measuring instrument for measuring and displaying a blood pressure of a subject~~,~~ ~~comprising:~~ in a non-invasive manner includes a pressure sensor for obtaining a pulse wave signal from a wrist of the subject; a pulse wave signal processing section for amplifying, filtering and ~~noise~~-noise-removing the pulse wave signal applied from the pressure sensor; ~~an~~ electrocardiogram ~~monitor~~ electrodes for ~~measuring a systolic blood pressure and a diastolic blood pressure and converting the measured results into electrical signals~~ detecting an electrocardiogram signal of the subject; an electrocardiogram signal processing section for amplifying, filtering and ~~noise~~-noise-removing the ~~converted~~

electrocardiogram ~~measurement signals applied from~~ signal detected by the electrocardiogram ~~monitor~~ electrodes; an A/D converting section for converting the ~~AC~~ analog signals, which are applied from both the pulse wave signal processing section and the electrocardiogram signal processing section, into ~~DC~~ digital signals; a controlling section for comparing and analyzing the pulse wave signal and the electrocardiogram ~~signals~~ signal applied through the A/D converting section to ~~operate~~ determine the blood pressure of the subject; and a display for displaying the blood pressure of the subject ~~operated at~~ determined by the controlling section.

[0012] ~~Further, it is preferred that the~~ The automatic blood pressure measuring instrument may further ~~comprises~~ include a program storing section for storing an operation program of the controlling section, and a data storing section for storing the pulse wave signal and the electrocardiogram ~~signals~~ signal applied from the A/D converting section for a predetermined time and storing ~~operation~~ data ~~operated at~~ determined by the controlling section.

[0013] ~~Here, the~~ The pulse wave signal processing section ~~comprises~~ may include a first impedance matching means for matching impedances of the inputted pulse wave signal and output signal, a ~~pulse wave signal amplifying means~~ first low-pass filter for filtering and amplifying the ~~signals~~ signal outputted from the first impedance matching means, and a first notch filter for removing a noise of a commercial power frequency from the ~~signals~~ signal amplified at the ~~pulse wave signal amplifying means~~ first low-pass filter.

[0014] ~~Moreover, the~~ The first notch filter ~~comprises~~ may include an operational (OP) amplifier for amplifying the ~~signals~~ signal amplified at the ~~pulse wave signal amplifying means~~ first low-pass filter and inputted to a non-inverting terminal thereof, a low-pass filter ~~provide~~ provided on a loop fed from an output terminal of the OP amplifier back to an inverting terminal and for removing the noise of the commercial power frequency, a first variable resistor connected in parallel with the non-inverting terminal of the OP amplifier, and a second variable resistor connected in parallel with the low-pass filter, whereby the first notch filter adjusts the cut-off frequency of the applied signals.

[0015] ~~Further, the~~ The electrocardiogram signal processing section ~~comprises~~ may include an amplifying section for amplifying the electrocardiogram ~~signals generated from~~ signal detected by the electrocardiogram ~~monitor~~ electrodes, and a filtering section for filtering and ~~noise~~ noise-removing the ~~signals~~ signal amplified at the amplifying section.

[0016] ~~Meanwhile, the~~ The filtering section ~~comprises~~ may include a fourth low-pass filter for removing a noise from the amplified ~~signals~~ signal applied from the amplifying section, a third impedance matching means for matching an impedance of the input signal applied from the fourth low-pass filter and an impedance of an output signal, and a second notch filter for removing the noise of the commercial power frequency ~~of~~ from the ~~signals~~ signal applied from the third impedance matching means.

[0017] The amplifying section ~~comprises~~ may include a first differential amplifier including a first gain adjusting means for adjusting a gain of the electrocardiogram ~~signals~~ signal measured from one side of a body of the subject, a second low-pass filter for removing a low band noise from the ~~adjusting signals~~ signal applied from the first gain adjusting means, and a first electrocardiogram signal amplifying means ~~from~~ for amplifying the ~~signals~~ signal filtered at the second low-pass filter; a second differential amplifier including a second gain adjusting means for adjusting a gain of the electrocardiogram ~~signals~~ signal measured from the other side of a body of the subject, a third low-pass filter for removing a low band noise from the ~~adjusting signals~~ signal applied from the second gain adjusting means, and a second electrocardiogram signal amplifying means ~~from~~ for amplifying the ~~signals~~ signal filtered at the third low-pass filter; and a second impedance matching means for matching an impedance with the filtering section when the ~~amplifying~~ amplified signals of the first and second differential amplifiers are applied.

[0018] ~~More preferably, the~~ The first and second differential amplifiers may further ~~comprises~~ include an inverse current preventing means connected to ~~an~~ input ~~terminal~~ terminals to which the ~~measurement signals are~~ electrocardiogram signal is applied from the electrocardiogram electrodes ~~of the electrocardiogram monitor~~.

[0019] In ~~order to accomplish these objects, there is provided~~ accordance with another aspect of the invention, an automatic blood pressure measuring method for measuring and displaying a blood pressure ~~from a wrist~~ of a subject in a non-invasive ~~method using the foregoing construction, comprising the steps of:~~ manner includes obtaining, amplifying, and filtering ~~a~~ an analog pulse wave signal from ~~the~~ a wrist of the subject; ~~measuring a systolic blood pressure and a diastolic blood pressure, and converting the measured results into electrical signals, and~~ obtaining, amplifying, and filtering ~~the converted results~~ an analog electrocardiogram signal of the subject; converting ~~AC~~ analog signals of the pulse wave signal and the electrocardiogram signal into ~~DC~~ digital signals after the amplifying and filtering ~~steps~~

operations; comparing the pulse wave signal and the electrocardiogram ~~signals~~ signal converted ~~at~~ in the converting ~~step~~ operation to ~~operate~~ determine the blood pressure of the subject; and displaying the blood pressure ~~operated~~ determined in the ~~operating step~~ comparing operation.

[0020] ~~Here, the~~ The comparing ~~and operating step comprising the substeps of: inputting the pulse wave and electrocardiogram signals;~~ operation includes comparing the pulse wave signal and the electrocardiogram ~~sensing signals inputted at the measuring step and operating~~ signal to determine a transition time parameter, an integral parameter, an area parameter, and a maximum amplitude parameter; and ~~combining constants representing a change quantity of the blood pressure according to the transition time parameter, the integral parameter, the area parameter and the maximum amplitude parameter operated at the comparing and operating substep and according to changes of the parameters, and operating the combined results, and operating~~ determining a maximum blood pressure and a minimum blood pressure of the subject based on the transition time parameter, the integral parameter, the area parameter, and the maximum amplitude parameter.

[0021] ~~Further, the~~ The transition time parameter is a time interval between a maximum ~~amplitudes~~ amplitude of a waveform of the pulse wave signal and ~~waveforms~~ a maximum amplitude of the electrocardiogram ~~signals~~ signal. The integral parameter is an integral value of a data value of the pulse wave signal between end points of a selected ~~range~~ zone of the pulse wave signal. The area parameter is an integral value of ~~an range~~ a difference between a data value of the pulse wave signal between end points of a selected zone of the pulse wave signal and a value of a base line joining ~~base lines on both sides~~ points where a waveform of the pulse wave signal intersects the end points of the selected ~~range~~ zone of the pulse wave signal. The maximum amplitude parameter is a maximum amplitude of a waveform of the pulse wave signal within a ~~designated~~ selected zone of the ~~integral and area parameters~~ digital pulse wave signal.

[0022] In other words, an aspect of the ~~present~~ invention ~~is characterized in that~~ enables anyone who is not a medical expert ~~can~~ to measure the blood pressure with ease by sensing ~~the~~ a pulse wave ~~at~~ signal with a pressure sensor, sensing ~~and comparing and analyzing systolic and diastolic pressures, measuring~~ an electrocardiogram signal with electrocardiogram electrodes, determining maximum and minimum blood pressures ~~through a series of operation processes~~ based on parameters determined by comparing the pulse wave signal and the

electrocardiogram signal, and displaying the ~~measured results~~ determined maximum and minimum blood pressures on ~~the~~ a display.

[0023] Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

~~Brief Description of Drawings~~

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] ~~The above objects, features and~~ These and/or other aspects and advantages of the ~~present~~ invention will become ~~more~~ apparent and more readily appreciated from the following ~~detailed~~ description ~~when~~ of various embodiments, taken in conjunction with the accompanying drawings~~,~~ ~~in~~ of which:

~~Figure 1 is a block diagram illustrating a telephone information offering system on the internet according to an embodiment of the present invention.~~

FIG. 1 is a perspective view ~~showing~~ of an automatic blood pressure measuring instrument according to ~~a preferred embodiment~~ an aspect of the ~~present~~ invention attached to an arm of a subject;

FIG. 2 is a bottom view of the automatic blood pressure measuring instrument shown in FIG. 1;

FIG. 3 is a side view of the automatic blood pressure measuring instrument shown in FIG. 1 attached to the arm of the subject;

FIG. 4 is a block diagram ~~showing an~~ of the automatic blood pressure measuring instrument ~~of the present invention~~ shown in FIG. 1;

FIG. 5 is a circuit diagram ~~showing~~ of a controlling section shown in FIG. 4;

FIG. 6 is a circuit diagram ~~showing~~ of a pulse wave signal processing section shown in FIG. 4;

FIG. 7 is a circuit diagram ~~showing~~ of an amplifying section of an ECG signal processing section shown in FIG. 4;

FIG. 8 is a circuit diagram ~~showing~~ of a filtering section of ~~an~~ the ECG signal processing section shown in FIG. 4;

FIG. 9 is a flow chart ~~showing~~ of an automatic blood pressure measuring method according to an aspect of the ~~present~~ invention;

FIG. 10 is a flow chart ~~showing~~ of a comparing and ~~operating steps~~ determining block shown in FIG. 9;

FIG. 11 is a graph of a pulse wave signal and an ECG signal showing ~~each parameter~~ parameters that are determined in FIG. 10;

~~FIG. 12 is a graph~~ FIGS. 12A though 12D are graphs showing ~~correlation between each parameter~~ changes in the parameters shown in FIG. 11 according to a change ~~of the~~ in a systolic blood pressure;

~~FIG. 13 is a graph~~ FIGS. 13A and 13B are graphs showing ~~correlation between each parameter~~ changes in two of the parameters shown in FIG. 11 according to a change ~~of the~~ in a diastolic blood pressure; and

FIG. 14 is a graph ~~tabling accumulative~~ of a cumulative distribution of ~~expectation and observation~~ expected values versus a cumulative distribution of observed values for a blood pressure determination algorithm using the parameters shown in FIG. 11.

~~Best Mode for Carrying Out the Invention~~

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0025] ~~A preferred embodiment~~ Reference will now be made in detail to various embodiments of the ~~present~~ invention, ~~will now be described with reference to~~ examples of which are shown in the accompanying drawings, wherein like reference numerals refer to like elements throughout. The embodiments are described below in order to explain the invention by referring to the figures.

[0026] FIG. 1 is a perspective view ~~showing~~ of an automatic blood pressure measuring instrument according to ~~a preferred embodiment~~ an aspect of the ~~present~~ invention attached to an arm of a subject. FIG. 2 is a bottom view of the automatic blood pressure measuring instrument shown in FIG. 1. FIG. 3 is a side view of the automatic blood pressure measuring instrument shown in FIG. 1 attached to the arm of the subject.

[0027] A reference numeral 100 indicates an automatic blood pressure measuring instrument, 11 indicates a display, 12 indicates manipulating keys, 13 indicates electrocardiogram (ECG)

electrode connection ports, 14 indicates a band, 15 indicates a buckle, 16 indicates a pressure sensor, and ~~17~~ ECG RA indicates ~~an~~ a second ECG ~~monitor~~ electrode (also shown in FIG. 7) fixed to a right arm of a subject.

[0028] The display 11 is for displaying a measured blood pressure. The manipulating keys 12 are for inputting a manipulation signal of a user. The ECG connection ports 13 are for connecting ~~with~~ a first ECG electrode ECG LL (shown in FIG. 7) and the second ECG ~~monitor 17~~ electrode ECG RA to the automatic blood pressure measuring instrument 100. The first ECG electrode ECG LL is fixed to a left leg of the subject. The first ECG electrode ECG LL and the second ECG ~~monitor 17 measures a systolic blood pressure and a diastolic blood pressure~~ electrode ECG RA detect an ECG signal of the subject. The band 14 supports the automatic blood pressure measuring instrument 100. The buckle 15 fixedly positions the automatic blood pressure measuring instrument 100 on a wrist of ~~a~~ the subject. The pressure sensor 16 senses a pulse ~~waves~~ wave of the subject and outputs a pulse wave signal.

[0029] In order to measure a blood pressure of the subject, first, the pressure sensor 16 is positioned ~~around~~ over an artery of the subject. Then, the band 14 is wound around a wrist of the subject, and then the buckle 15 is fastened. Subsequently, the first ECG electrode ECG LL and the second ECG ~~monitor 17 is~~ electrode ECG RA are connected to the ECG connection ports 13. Then, ~~a~~ the first ECG electrode ~~(ECG LL, FIG. 7)~~ ECG LL is fixed to ~~a~~ the left ~~foot~~ leg of the subject, while ~~a~~ the second ECG electrode ~~(ECG RA, FIG. 7)~~ ECG RA is ~~attached~~ fixed to ~~a~~ the right ~~foot~~ arm of the subject.

[0030] Therefore, the automatic blood pressure measuring instrument 100 obtains a pulse wave signal of the subject using the pressure sensor 16. ~~The~~ and obtains an ECG signal of the subject using the first ECG electrode ECG LL and the second ECG ~~monitor 17 measures systolic and diastolic blood pressures of the subject~~ electrode ECG RA. Thus, a controlling section 70 compares and ~~operates~~ analyzes both signals to ~~display~~ determine the maximum and minimum blood pressures and display them on the display 11.

[0031] FIG. 4 is a block diagram ~~showing an~~ of the automatic blood pressure measuring instrument ~~of~~ 100 according to an aspect of the ~~present~~ invention shown in FIG. 1.

[0032] Of the reference numerals, 11 is for a display, 16 is for a pressure sensor, ~~17 is~~ ECG LL and ECG RA are for ~~an~~ ECG ~~monitor~~ electrodes, 20 is for a pulse wave signal

processing section, 30 is for an amplifying section, 40 is for a filtering section, 50 is for an ECG signal processing section, 61 is for a program storing section, 62 is for a data storing section, 63 is for an A/D converting section, 70 is for a controlling section, 80 is for an inputting section, 90 is for an interface, and 200 is for a computer.

[0033] The pulse wave signal processing section 20 amplifies and filters a pulse wave signal applied from the pressure sensor 16. The amplifying section 30 amplifies ~~a~~ an ECG signal ~~applied from~~ detected by the ECG ~~monitor 17~~ electrodes ECG LL and ECG RA. The filtering section 40 filters an applied low band signal. The program storing section 61 ~~is stored with~~ stores a drive program together with set data. The data storing section 62 ~~is stored with a measured~~ stores the pulse wave signal and the ECG signal together with ~~operated~~ determined data. The A/D converting section converts an ~~AC~~ analog signal into a ~~DC~~ digital signal. The controlling section ~~operates~~ determines the maximum blood pressure and the minimum blood pressure. The inputting section 80 is inputted by a manipulation signal of a user. The interface 90 is connected with an external instrument.

[0034] The pressure sensor 16 fixed to the wrist of the subject generates a pulse wave caused by a pressure of blood flowing through the artery. That is, the pressure sensor 16 fixed over the ~~blood vessel~~ artery is subjected to impetus which the blood lends to the ~~blood vessel~~ artery, so that the pressure sensor 16 generates the pulse wave. The pulse wave applied from the pressure sensor 16 is inputted into the pulse wave signal processing section 20, and is amplified there. As a result, the pulse wave is subjected to filtering of a low band signal and removal of a noise. Then, the signal from which the noise is removed is applied to the A/D converting section 63, and is subjected to conversion from an ~~AC~~ analog signal to a ~~DC~~ digital signal, and then is applied to the controlling section 70.

[0035] Further, the ECG ~~monitor 17 measures a systolic blood pressure as well as a diastolic blood pressure to generate~~ electrodes ECG LL and ECG RA detect an ECG ~~signals~~ signal. The ~~generated~~ detected ECG ~~signals are~~ signal is applied to and amplified by the ECG signal processing section 50, and ~~are~~ is then applied to the A/D converting section 63. The A/D converting section 63 converts the applied ~~AC~~ analog ~~signals~~ ECG signal into ~~DC signals~~ a digital ECG signal to apply to the controlling section 70.

[0036] FIG. 5 is a circuit diagram of the controlling section 70 shown in FIG. 4. Here, the controlling section 70 is capable of performing arithmetical operation of data of 8 bits as shown in FIG. 5. To this end, an 8051 microprocessor having a 16-bit data address is preferably used. The controlling section 70 has four input/output ports, so that it is capable of directly receiving and outputting data of the data storing section 62 and the A/D converting section 63 relative to the outside. Further, the controlling section 70 has a built-in serial port, so that it is capable of directly receiving and outputting data from/to the computer 200 through the interface 90 using the serial port. The controlling section is capable of not only storing a program to the program storing section 61, but also performing various records related to bit operation, controlling, etc., using an SFR (special function register).

[0037] Here, it is preferred that the data storing section 62 makes use of an SRAM in order to avoid a work such as a refresh. The data storing section 62 stores data obtained by the A/D converting section 63 for a predetermined time under the control of the controlling section 70, and performs comparison and analysis of the pulse wave signal and the ECG ~~signals, which are applied~~ signal based on the drive program stored ~~at~~ in the program storing section 61. Then, the data storing section 62 ~~operates a transition time parameter (or ΔT parameter) c,~~ determines an integral parameter a, an area parameter b, an transition time parameter c and ~~the~~ a maximum amplitude parameter ~~(or Max)~~ d, and then applies the ~~operated~~ determined parameters a, b, c and d to a blood pressure determination algorithm, which will be mentioned below, and finally ~~operates~~ determines values of the maximum and minimum blood pressures. The controlling section 70 stores the ~~operated~~ determined data ~~to~~ in the data storing section 62, and controls the display 11 to ~~force~~ display the ~~operated~~ determined values of the maximum and minimum blood pressures ~~to be displayed~~. Additionally, the controlling section 70 is capable of ~~operating~~ determining a pulse rate or frequency of the subject based on the applied measurement signals. ~~This operation~~ A pulse rate or frequency determination algorithm for determining the pulse rate or frequency is preferably stored ~~at~~ in the program storing section 61.

[0038] Here, the controlling section 70 checks whether there is connection to an external instrument by means of the interface 90. If the connection to an external instrument such as the computer 200, etc., is present, the controlling section 70 transmits the ~~operated~~ determined data to the computer 200 through the interface 90.

[0039] A construction of the pulse wave signal processing section 20 and the ECG signal processing section 50 as mentioned above is shown in detail in ~~FIGs.~~ FIGS. 6 to 8. Hereinafter, the construction will be described in detail with reference to ~~FIGs.~~ FIGS. 6 to 8.

[0040] FIG. 6 is a circuit diagram of the pulse wave signal processing section ~~of~~ 20 shown in FIG. 4.

[0041] Of the reference numerals, 21 indicates a first impedance matching means, 22 indicates a ~~pulse wave signal amplifying means~~ first low-pass filer, and 23 indicates a first notch filter.

[0042] The first impedance matching means 21 matches an impedance of the pulse wave signal applied from the pressure sensor 16 to an impedance of an output terminal. The ~~pulse wave signal amplifying means~~ first low-pass filter 22 filters and amplifies a low band signal to remove a noise. The first notch filter 23 removes a noise of a commercial power frequency.

[0043] When the measurement signals are applied from the pressure sensor 16, these signals are applied to inverting and non-inverting terminals of a first operational (OP) amplifier (OP1) through first and second resistors (R1 and R2) connected in ~~parallelism~~ parallel, and then their voltages are amplified by the first OP amplifier OP1. Here, because the applied measurement signals of the pressure sensor 16 ~~has~~ have a higher impedance at an output terminal of the first OP amplifier OP1, both the first resistor R1 and the first OP amplifier OP1 match an impedance at each input terminal to that at each output terminal. That is, according to a rule of voltage ~~distribution~~ division, when a resistance of the R1 is increased, an input voltage is lowered. The lowered input voltage is amplified at the first OP amplifier OP1, so that the impedance of the R1 is matched with that of a circuit connected to the first OP amplifier OP1. Therefore, the signals outputted from the first OP amplifier OP1 through the process as mentioned above are subjected to the foregoing impedance matching process and the amplifying process through a fourth resistor R4, and a second OP amplifier OP2.

[0044] The signals outputted from the first impedance matching means 21 pass through a sixth resistor R6, of ~~a~~ the first low-pass filter 22, and are subjected to removal of a low band signal between 20 and 40 Hz by means of a seventh resistor R7, and a second capacitor C2, and are inputted into an inverting terminal of a third OP amplifier OP3. Then, the signals inputted into the third OP amplifier OP3 are subjected to amplification, and pass through a tenth

resistor R10, and are filtered by an eleventh resistor R11 and a fourth capacitor C4. Subsequently, the ~~secondary~~ filtered pulse ~~waves~~ wave signals are applied to a fourth OP amplifier OP4. The OP4 amplifies the ~~imputed~~ inputted signals to apply to the first notch filter 23.

[0045] The first notch filter 23 includes a fourteenth resistor R14 connected to an output terminal of the fourth OP amplifier OP4 in series, a first variable resistor, VR1 connected to the R14 in parallel, a fifth OP amplifier OP5 having ~~an inverting~~ a non-inverting terminal connected to the R14 in series and an output terminal designed to perform negative feedback to a ~~non-inverting~~ an inverting terminal of the fifth OP amplifier OP5, a fifth capacitor C5 connected to a negative feedback loop of the fifth OP amplifier OP5 in series, a sixth capacitor C6 connected to the C5 in parallel and to the ~~non-inverting~~ inverting terminal of the fifth OP amplifier OP5 in series, a fifteenth resistor R15 connected to the C5 in parallel, and a second variable resistor, VR2 having one side grounded and the other side connected to a ~~sixteenth~~ fifty-first resistor ~~R16~~ R51, which is connected to the R15 in parallel.

[0046] The pulse wave signal applied from the first low-pass filter 22 is inputted into the first notch filter 23, particularly, the non-inverting terminal of the fifth OP amplifier OP5 via the R14 and the VR1. The pulse wave signal inputted into the fifth OP amplifier OP5 is subjected to amplification and ~~are~~ is outputted. At this time, the R15 and the C5, which are connected in parallel on the negative feedback loop, remove a noise at a commercial power frequency of 60 Hz, which is subjected to feedback at the output terminal of the fifth OP amplifier OP5. Here, the VR1 and the VR2 are each varied to adjust the commercial power frequency to 60 Hz, so that the commercial power frequency can be matched to a commercial power frequency of a system connected with the output terminal of the first notch filter 23.

[0047] FIG. 7 is a circuit diagram ~~showing an~~ of the amplifying section 30 of ~~an~~ the ECG signal processing section 50 shown in FIG. 4.

[0048] Of the reference numerals or symbols, 30a is for a first differential amplifier, 30b is for a second differential amplifier, ~~an~~ ECG LL is for ~~a~~ the first ECG electrode, ~~an~~ ECG RA is for ~~a~~ the second ECG electrode, 31 is for a first inverse current preventing means, 32 is for a first gain adjusting means, 33 is for a first ECG signal amplifying means, 34 is for a second low-pass filter, 35 is for a second inverse current preventing means, 36 is for a second gain adjusting

means, 37 is for a second ECG signal amplifying means, 38 is for a third low-pass filter, and 39 is for a second impedance matching means.

[0049] The first and second inverse current preventing means 31 and 35 prevent an inverse current generated at an input power source. The first and second ECG signal amplifying means 33 and 37 amplify inputted signals. The second and third low-pass filters 34 and 38 filter signals of a low band frequency among inputted signals. The second impedance matching means 39 matches an impedance of inputted signals to that of outputted signals.

[0050] In the first differential amplifier 30a, the first gain adjusting means 32 is connected with the first ECG electrode, ECG LL ~~of the ECG monitor 17~~ in series. The inverse current preventing means 31 is connected between the ECG LL and the first gain adjusting means 32, and includes first and second power source terminals, +BS1 and –BS1 connected in parallel, and first and second diodes, D1 and D2 connected to the first and second power source terminals, +BS1 and –BS1 in an opposite direction to each other. Here, the first gain adjusting means 32 includes a sixth OP amplifier OP6. A third power source, +BM is applied to a terminal 1 of the sixth OP amplifier OP6, and a fourth power source, -BM is applied to a terminal 2 of the sixth OP amplifier OP6. The third power source, +BM is connected in parallel with eighth and ninth capacitors C8 and C9, each of which is grounded on one side. The fourth power source, -BM is connected in parallel with tenth and eleventh capacitors C10 and C11, each of which is grounded on one side. Further, the first gain adjusting means 32 is connected in parallel with the second impedance matching means 39, the first ECG signal amplifying means 33 and the second low-pass filter 34. Here, the first ECG signal amplifying means 33 includes a seventh OP amplifier OP7, an output terminal of which is subjected to negative feedback to an inverting terminal thereof. A negative feedback loop of the inverting terminal of the seventh OP amplifier OP7 is connected with an output terminal of the second low-pass filter 34. Further, the seventh OP amplifier OP7 of the first ECG signal amplifying means 33 has the output terminal connected to an output terminal of the first gain adjusting means 32.

[0051] In the second differential amplifier 30b, the second gain adjusting means 36 is connected with the second ECG electrode, ECG RA ~~of the ECG monitor 17~~ in series. The second inverse current preventing means 35 is connected between the ECG RA and the second gain adjusting means 36, and includes fifth and sixth power source terminals, +BS2 and –BS2 connected in parallel, and third and fourth diodes, D3 and D4 connected to the fifth and

sixth power source terminals, +BS2 and –BS2 in an opposite direction to each other. Here, the second gain adjusting means 36 includes a ninth OP amplifier OP9. A seventh power source, -BM2 is applied to a terminal 1 of the ninth OP amplifier OP9, and an eighth power source, +BM2 is applied to a terminal 4 of the ninth OP amplifier OP9. The seventh power source, -BM2 is connected in parallel with sixteenth and seventeenth capacitors C16 and C17, each of which is grounded on one side. The eighth power source, +BM2 is connected in parallel with fourteenth and fifteenth capacitors C14 and C15, each of which is grounded on one side. Further, the second gain adjusting means 36 is connected in parallel with the second impedance matching means 39, the second ECG signal amplifying means 37 and the third low-pass filter 38. Here, the second ECG signal amplifying means 37 includes a tenth OP amplifier OP10, an output terminal of which is subjected to negative feedback to an inverting terminal thereof. A negative feedback loop of the inverting terminal of the first OP amplifier OP10 is connected with an output terminal of the third low-pass filter 38. Further, the ninth OP amplifier OP9 of the second ECG signal amplifying means 37 has the output terminal connected to an output terminal of the second gain adjusting means 36.

[0052] The first and second differential amplifiers 30a and 30b constructed as the foregoing are connected in parallel not only by seventh and thirteenth capacitors C7 and C13 at the rear ends of sixteenth and twenty-seventh resistors R16 and R27 of the input line, but also by seventeenth and twenty-eighth resistors R17 and R28 on the negative feedback loops, each of which is connected to each inverting terminal of the sixth and ninth OP ~~amplifier~~ amplifiers OP6 and OP9. Further, the first differential amplifier 30a is connected to an inverting terminal of the second impedance matching means 39, while the second differential amplifier 30b is connected to a non-inverting terminal of the second impedance matching means 39.

[0053] ~~Signals applied at~~ ECG signals detected by the first ECG electrode, ECG LL are applied to the first gain adjusting means 32 through the sixteenth resistor R16. Here, since ECG signals ~~applied at~~ detected by the first ECG electrode, ECG LL typically have high impedances, their impedances are not matched with system-side ones, so that there is possibility to give a fatal damage to the system. Thus, input impedances are matched with the system side by the first gain adjusting means 32, and thereby a gain of output signals is adjusted to be lowered. Here, it is preferred that the R16 has a high resistance value in order to apply a rule of voltage ~~distribution~~ division. Therefore, the measurement signals applied from

the first ECG electrode, ECG LL are subjected to voltage division, so that a gain of the signals outputted from the sixth OP amplifier OP6 is lowered. Further, a current is applied to the first and second power source terminals, +BS1 and –BS1, so that the measurement signals have an increased current. The first and second power source terminals, +BS1 and –BS1 are respectively provided with the first and second diodes, D1 and D2, ~~respectively,~~ and thus the circuit is prevented from being damaged by an inverse current.

[0054] The measurement signals outputted from the first gain adjusting means 32 are inputted into a non-inverting terminal of the first ECG signal amplifying means 33 and a non-inverting terminal of the second low-pass filter 34. Here, the second low-pass filter 34 has a feedback loop from an output terminal of the eighth OP amplifier OP8 through the twelfth capacitor C12 to a terminal 1 of the eighth OP amplifier OP8. At this time, signals ranging from 20 to 40 Hz are filtered by the twelfth capacitor C12 ~~on~~ in the feedback loop.

[0055] Therefore, the measurement signals filtered at the second low-pass filter 34 are inputted into an inverting terminal of the seventh OP amplifier OP7 of the first ECG signal amplifying means 33, and then are subjected to negative feedback from an output terminal of the seventh OP amplifier OP7 through a twenty-third resistor R23 to the inverting terminal of the seventh OP amplifier OP7, so that they are amplified and applied to the inverting terminal of the second impedance matching means 39.

[0056] ~~Signals applied at~~ An ECG signal detected by the second ECG electrode, ECG RA ~~are~~ is applied to the second gain adjusting means 36 through the twenty-seventh resistor R27. Here, the second ECG electrode, ECG RA is considered as an external resistor as mentioned above. Since the second ECG electrode, ECG RA and the twenty-seventh resistor R27 are connected in parallel, a circuit line tapped between them is connected to a non-inverting terminal of the ninth OP amplifier OP9. Therefore, according to voltage ~~distribution~~ division of the second ECG electrode, ECG RA and the twenty-seventh resistor R27, the ~~measurement signals~~ ECG signal applied from the second ECG electrode, ECG RA ~~are~~ is subjected to voltage division and ~~are~~ is inputted into the ninth OP amplifier OP9, so that a gain of the ~~signals~~ signal is lowered. At this time, a current is applied to the fifth and sixth power source terminals, +BS2 and –BS2, so that the ~~measurement signals have~~ ECG signal has an increased current. The power source terminals, +BS2 and –BS2 are ~~each~~ provided with the second inverse current

preventing means 35 consisting of the third and fourth diodes, D3 and D4, and thus the circuit is prevented from being damaged by an inverse current.

[0057] The ~~measurement signals~~ ECG signal outputted from the second gain adjusting means 36 ~~are~~ is inputted into a non-inverting terminal of the second ECG signal amplifying means 37 and a non-inverting terminal of the third low-pass filter 38. Here, the third low-pass filter 38 has a feedback loop from an output terminal of the eleventh OP amplifier OP11 through the eighteenth capacitor C18 to a terminal 1 of the eleventh OP amplifier OP11, and thereby signals between 20 and 40 Hz are filtered.

[0058] Therefore, the measurement signals filtered at the third low-pass filter 38 are inputted into an inverting terminal of the tenth OP amplifier OP10 of the second ECG signal amplifying means 37, and then are subjected to negative feedback from an output terminal of the tenth OP amplifier OP10 through a thirty-fourth resistor R34 to the inverting terminal of the tenth OP amplifier OP10, so that they are amplified and applied to the non-inverting terminal of the second impedance matching means 39.

[0059] Thus, an output terminal of the twelfth OP amplifier OP12 of the second impedance matching means 39 is connected with a fortieth resistor R40 and forms a negative feedback loop together with an inverting terminal of the twelfth OP amplifier OP12. A voltage inputted into a thirty-seventh resistor R37 provided on an input side of the twelfth OP amplifier OP12 and a voltage inputted into the fortieth resistor R40 of the negative feedback loop are divided and inputted into the twelfth OP amplifier OP12, thus being matched with an impedance of the output terminal and applied to a filtering section 40.

[0060] FIG. 8 is a circuit diagram ~~showing~~ of the filtering section 40 of the ECG signal processing section 50 shown in FIG. 4.

[0061] Of the reference numerals, 40 indicates the filtering section, 41 indicates a fourth low-pass filter, 42 indicates a third impedance matching means, and 43 ~~is~~ indicates a second notch filter.

[0062] The fourth low-pass filter 41 removes a noise of low band from applied signals. The third impedance matching means 42 matches an impedance of an input terminal with that of an output terminal. The second notch filter 43 removes a noise of a commercial power frequency.

[0063] In the fourth low-pass filter 41, an input terminal is connected in parallel with a nineteenth capacitor C19, and is connected in series with a forty-first resistor R41, a forty-third resistor R43 and an inverting terminal of a thirteenth OP amplifier OP13. A twentieth capacitor C20 is connected in parallel between the forty-first resistor R41, the forty-third resistor R43. A forty-fourth resistor R44 is connected to the nineteenth and twentieth capacitors C19 and C20 on one side and to a non-inverting terminal of the thirteenth OP amplifier OP13 on the other side. Here, the thirteenth OP amplifier OP13 has a negative feedback loop from an output terminal to the non-inverting terminal. Here, a forty-second resistor R42 and a twenty-first capacitor C21 are each connected in parallel to the negative feedback loop.

[0064] The third impedance matching means 42 has a forty-fifth resistor 45 R45 connected in series with the output terminal of the fourth low-pass filter 41. The forty-fifth resistor 45 R45 is connected in series to an inverting terminal of a fourteenth OP amplifier OP14. A forty-sixth resistor R46 is connected to a non-inverting terminal of the fourteenth OP amplifier OP14 on one side, and is grounded on the other side. The fourteenth OP amplifier OP14 has a terminal 1 to which a commercial power source, VCC1 is applied. The commercial power source, VCC1 is connected in parallel with twenty-fourth and twenty-fifth capacitors C24 and C25. The fourteenth OP amplifier OP14 has a terminal 4 to which another commercial power source, VCC2 is applied. The commercial power source, VCC2 is connected in parallel with twenty-second and twenty-third capacitors C22 and C23. Thus, a noise is removed from the applied power source. The fourteenth OP amplifier OP14 has a negative feedback loop from an output terminal to an inverting terminal. A forty-seventh resistor 47 is connected to the negative feedback loop of the fourteenth OP amplifier OP14.

[0065] The second notch filter 43 has a forty-ninth resistor R49, one side of which is connected in series with the third impedance matching means 42 and the other side is connected in series with a non-inverting terminal of a fifteenth OP amplifier OP15. Here, a fourth variable resistor, VR4 is connected in parallel between the forty-ninth resistor R49 and the non-inverting terminal of the fifteenth OP amplifier OP15. Further, the fifteenth OP amplifier OP15 is formed with a feedback loop from an output terminal to an inverting terminal. A fiftieth resistor R50 and a twenty-seventh capacitor C27 are each connected in parallel to the feedback loop of the fifteenth OP amplifier OP15. A third variable resistor, VR3 is connected in parallel with the fiftieth resistor R50 through a forty-eighth resistor R48. A twenty-sixth capacitor C26 is

connected in parallel with the fiftieth resistor R50 and the twenty-seventh capacitor C27 on one side, and with the inverting terminal of the fifteenth OP amplifier OP15 on the other side.

[0066] From the measurement signals applied at the amplifying section 30, low band signals between 20 and 40 Hz are filtered by the forty-first and forty-third resistors R41 and R43, and by the nineteenth and twentieth capacitors C19 and C20. The filtered signals are applied to and amplified by the thirteenth OP amplifier OP13. Here, the amplified signals are applied to the negative feedback loop of the output terminal again, and are filtered by the forty-second resistor R42 and the twenty-first capacitor C21, and are applied to the inverting terminal of the thirteenth OP amplifier OP13.

[0067] As mentioned above, the signals filtered at the fourth low-pass filter 41 are inputted into the inverting terminal of the fourteenth OP amplifier OP14 through the forty-fifth resistor R45 of the third impedance matching means 42, so that a voltage amplified to the output terminal is inputted into the inverting terminal again along the negative feedback loop. Therefore, according to a rule of voltage ~~distribution~~ division, the inputted signals are subjected to voltage division at the forty-fifth and forty-seventh resistors R45 and R47. The voltage-divided signals are amplified again and outputted, thus being matched with an impedance of the second notch filter 43.

[0068] The signals outputted from the third impedance matching means 42 are applied to the non-inverting terminal of the fifteenth OP amplifier OP15 through the forty-ninth resistor R49 of the second notch filter 43. Here, the fourth variable resistor VR4 adjusts a commercial power frequency of the inputted signals. That is, the commercial power frequency is ideally 60 Hz, but is from 58 to 59 Hz in reality, so that it is adjusted and matched at the fourth variable resistor VR4. The signals amplified at the fifteenth OP amplifier OP15 are subjected to negative feedback, and are filtered at the fiftieth resistor R50 and the twenty-seventh capacitor C27, and are subjected to removal of a noise of the commercial power frequency. At this time, the signals are adjusted to the commercial power frequency by adjustment of the third and fourth variable resistors VR3 and VR4.

[0069] FIG. 9 is a flow chart ~~showing~~ of an automatic blood pressure measuring method according to an aspect of the ~~present~~ invention. An operation of the ~~foregoing construction~~

example of the ~~present~~ invention described above will be described in detail with reference to FIG. 9.

[0070] The automatic blood pressure measuring instrument 100 according to an aspect of the ~~present invention~~ is fixed to the right wrist of the subject so as to position the pressure sensor 16 over the artery of the subject. The first ECG electrode ECG LL and the second ECG ~~monitor 17 is~~ electrode ECG RA are connected to the ECG connection ports 13 provided on one side of the automatic blood pressure measuring instrument 100. The first ECG electrode ECG LL ~~of the ECG monitor 17~~ is fixed to the left ~~ankle~~ leg of the subject, while the second ECG electrode ECG RA is fixed to the right arm of the subject.

[0071] A power switch provided on the upper surface of the automatic blood pressure measuring instrument is turned on (block S11), the display 11 is operated (block S12), and the pressure sensor 16, the first ECG electrode ECG LL, and the second ECG ~~monitor 17~~ electrode ECG RA generate sensing signals (blocks S13 and S14). Therefore, the pulse wave signal sensed at the pressure sensor 16 is applied to the pulse wave signal processing section 20, so that the ~~signals~~ pulse wave signal outputted from the pressure sensor 16 ~~have~~ has an impedance matched with that of the signals outputted from the first impedance matching means 21, and are amplified by the ~~pulse wave amplifying means~~ first low-pass filter 22, and are applied to the first notch filter 23 again, and are subjected to noise removal at the commercial power frequency of 60 Hz (block S15). Then, the ~~AC~~ analog signals free from a noise are converted into ~~DC ones at~~ digital signals by the A/D converting section 63 and then applied to the controlling section 70 (block S16).

[0072] Further, the ECG ~~measurement signals generated at~~ signal detected by the first ECG electrode ECG LL and the second ECG ~~monitor 17 are~~ electrode ECG RA is applied to and amplified at the amplifying section 30. That is, the ~~signals measured~~ ECG signal detected at the left leg ~~are~~ by the first ECG electrode ECG LL is amplified at the first differential amplifier 30a, and ~~are~~ is applied to the inverting terminal of the second impedance matching means 39, while the ~~signals measured~~ ECG signal detected at the right arm ~~are~~ by the second ECG electrode ECG RA is amplified at the second differential amplifier 30b, and are applied to the non-inverting terminal of the second impedance matching means 39, so that both signals are matched with an impedance of the filtering section 40 and are applied to the filtering section 40.

[0073] Thus, the amplified signals are applied to the filtering section 40, the fourth low-pass filter 41 allows for pass only some of the amplified signals belonging to a predetermined band, but removes the rest. The filtered ECG measurement signals are applied to the third impedance matching means 42. The third impedance matching means 42 performs buffering in order to match the inputted signals to the second notch filter 43 on the output side of the filtering section 40. The buffered signals are applied to the second notch filter 43, and subjected to noise removal of the commercial power frequency of 60 Hz, and applied to the A/D converting section 63, so that they are subjected to conversion from the ~~AC~~ analog signals to ~~DC~~ digital signals and applied to the controlling section (blocks S15 and S16).

[0074] The controlling section 70 stores the applied measurement signals ~~on~~ in the data storing section 62 for a predetermined time, ~~and~~ reads ~~out~~ them out, ~~and~~ compares them and ~~operates respective data, and obtains a transition time (ΔT) parameter, an~~ determines the integral parameter ~~and an~~ a, the area parameter b, the transition time parameter c, and the maximum amplitude parameter d. The controlling section 70 ~~controls to apply an operation~~ uses a blood pressure determination algorithm stored ~~at~~ in the program storing section 61 ~~to each parameter,~~ that is a function of these parameters to ~~operate~~ determine the maximum and minimum blood pressures, and ~~to display~~ displays these blood pressures on the display 11 (blocks S17 and S18).

[0075] Further, the controlling section 70 ~~operates~~ determines pulse ~~number~~ rate and diagnosis result using the measurement signals stored ~~at~~ in the data storing section 62 for a predetermined time. That is, the controlling section 70 controls to apply the measurement signals to ~~an operation~~ a pulse rate and diagnosis result algorithm for the pulse ~~number~~ rate and diagnosis result stored ~~at~~ in the data storing section 62, to ~~operate~~ determine the pulse rate and ~~frequency~~ diagnosis result to display them on the display 11.

[0076] Here, the blood pressure, the pulse ~~number~~ rate and the ~~pulse~~ diagnosis result are displayed ~~through~~ on the LCD (Liquid Crystal Display) 11, so that limitation to a displayed quantity is removed. The display 11 is adapted to display the maximum and minimum blood pressure measured by the automatic blood pressure measuring instrument 100, as well as the pulse ~~number~~ rate and the present ~~pulse~~ diagnosis result. Further, the display 11 is designed to display cardiovascular disease codes, an output mode of which is developed based on

expected cardiovascular diseases. Table 1 shows items displayed on the display 11 including the disease codes as one example.

~~Table 1: example of expected disease codes~~

~~symptom~~	~~code~~	~~symptom~~	~~code~~
~~normal~~	~~Nomal~~	~~unstable high blood pressure~~	~~H-Case S~~
~~high normal blood pressure~~	~~H-Case 0~~	~~first period of high blood pressure~~	~~H-Case 1~~
~~low blood pressure~~	~~L-Case~~	~~second period of high blood pressure~~	~~H-Case 2~~
~~slow pulse~~	~~B-Case~~	~~third period of high blood pressure~~	~~H-Case 3~~
~~weak pulse~~	~~T-Case~~	~~fourth period of high blood pressure~~	~~H-Case 4~~
~~weak beat of artrim~~	~~A-Case~~	~~re-measuring request~~	~~ERROR~~

Table 1—Examples of Expected Disease Codes

Symptom	**Code**	**Symptom**	**Code**
Normal	Normal	Unstable high blood pressure	H-Case S
High normal blood pressure	H-Case 0	First period of high blood pressure	H-Case 1
Low blood pressure	L-Case	Second period of high blood pressure	H-Case 2
Slow pulse	B-Case	Third period of high blood pressure	H-Case 3
Weak pulse	T-Case	Fourth period of high blood pressure	H-Case 4
Weak beat of atrium	A-Case	Re-measuring request	ERROR

[0077] FIG. 10 is a flow chart ~~showing~~ of the comparing and ~~operating steps~~ determining block S17 shown in FIG. 9. FIG. 11 is a graph of a pulse wave signal and an ECG signal showing ~~each parameter~~ parameters that are determined in FIG. 10. The comparing and ~~operating steps~~ block S17 will be described in detail with reference to ~~FIGs.~~ FIGS. 10 and 11.

[0078] When the ~~measurement signals~~ pulse wave signal and the ECG signal generated from the pressure sensor 16 and the ECG ~~monitor 17~~ electrodes ECG LL and ECG RA are temporarily stored ~~on~~ in the data storing section 62 through the A/D converting section 63 (blocks S21 and S22), the controlling section 70 reads out the measurement signals stored ~~on~~ in the data storing section 62 after a predetermined time lapses away, ~~and~~ compares waveforms of the two signals (block S23) and ~~operates~~ determines each parameter. That is, as shown in FIG. 11, the pulse wave signal and the ECG ~~measurement~~ signal are compared and analyzed, and each parameter is ~~operated~~ determined. Of the reference symbols, a is the integral parameter, b is the area parameter, c is the transition time ~~(ΔT)~~ parameter, and d is the maximum amplitude parameter.

[0079] Thus, the controlling section 70 reads out the data stored temporarily ~~on~~ in the data storing section 62, ~~and~~ selects a ~~predetermined~~ zone, and ~~operates~~ determines the integral parameter a according to the following equation with an integral value for data ~~value~~ values between end points of the selected zone (block S24).

~~$< PSTYLELSPACE = 130 > f_{output}(n) = \sum_{k=1}^{n-1} f_{input}(k) + [(f_{input}(n-1) + f_{input}(n))/2] * \Delta T$~~

$$f_{output}(n) = \sum_{k=1}^{n} [(f_{input}(k-1) + f_{input}(k))/2] * \Delta t$$

Here, f() is a data value, n is a number of sampling intervals each having a width Δt on the horizontal axis in FIG. 11, k= 0 is the left end point of the selected zone and k=n is the right end point of the selected zone.

[0080] Further, the controlling section 70 sets a base line joining end points of the area selected within the predetermined zone, and integrates a zone of the upper side of the base line to obtain the area parameter b (block S25). This calculation value will be always a positive value, and can be measured as the whole area between the waveform and the base line, and can represent the area in terms of a unit obtained by multiplying a unit of the amplitude ~~and~~ by a unit of the ~~horizon~~ horizontal axis, and can be calculated using ~~a formula given below~~ the following equation.

$$< PSTYLELSPACE = 130 > f_{output}(n) = \frac{}{\sum_{k=1}^{n-1}(|f_{input}(n-1) - y(n-1)| + |(f_{input}(n-1) + y(n))/2|) * \Delta T}$$

$$f_{output}(n) = \sum_{k=1}^{n}[(|f_{input}(k-1) - y(k-1)| + |f_{input}(k) - y(k)|)/2] * \Delta t$$

Here, f() ~~represents~~ is a data value, ~~of data, and~~ y() is a value of the line joining the end points, ~~and ΔT~~ n is a number of sampling ~~interval of the horizon~~ intervals each having a width Δt on the horizontal axis in FIG. 11, k= 0 is the left end point of the selected zone and k=n is the right end point of the selected zone.

[0081] The controlling section 70 ~~operates~~ determines a time interval between the maximum amplitudes of an ECG waveform and a waveform detected from the pressure sensor fixed to the wrist, and ~~operates~~ determines the ~~ΔT~~ transition time parameter c (block S26), and ~~operates~~ determines the maximum amplitude within a designated range of the integral and area parameters a and b, ~~and~~ thus ~~operating~~ determining the maximum amplitude parameter d (block S27). The maximum amplitude parameter d derives a change of the maximum amplitude value of the detected waveform according to a pressure change.

[0082] Here, the ~~respective~~ parameters a, b, c and d ~~operated~~ determined in the foregoing way represent constant tendencies of the systolic and diastolic blood pressures. This linear change is shown in ~~FIGs. 12~~ FIGS. 12A through 12D and ~~13~~ FIGS. 13A and 13B.

[0083] FIG. ~~12a~~ 12A is a graph showing a ~~value of~~ change in the transition time parameter c (ΔT) according to a change ~~of~~ in the systolic blood pressure. It can be seen that as the systolic blood pressure becomes higher, a time interval between maximum amplitudes ~~becomes narrower~~ decreases. Thus, a value of the transition time parameter c also decreases.

[0084] FIG. ~~12b~~ 12B is a graph showing a change ~~of~~ in the integral parameter a according to a change in the systolic blood pressure. It can be seen that as the systolic blood pressure becomes higher, an integral value ~~is decreased~~ decreases within a predetermined range. Thus, a value of the integral parameter a ~~is also decreased~~ decreases.

[0085] ~~Further,~~ FIG. ~~12c~~ 12C is a graph showing a change ~~of~~ in the area parameter b according to a change in the systolic blood pressure. As the systolic blood pressure becomes

higher, a value of data ~~is increased~~ increases within a predetermined area. Thus, a value of the area parameter b ~~is increased~~ also increases.

[0086] FIG. ~~12d~~ 12D is a graph showing a change ~~of~~ in the maximum amplitude parameter d (Max) according to a change in the systolic blood pressure. As the systolic blood pressure becomes higher, a value of the maximum amplitude parameter d ~~is also increased~~ increases.

[0087] ~~Further, FIG. 13 is a graph showing a change of each parameter according to a change of the systolic blood pressure.~~ FIG. ~~13a~~ 13A is a graph showing a ~~value of~~ change in the transition time parameter c~~, which is linearly decreased as~~ (ΔT) according to a change in the diastolic blood pressure. As the diastolic blood pressure becomes higher, a value of the transition time parameter c linearly decreases.

[0088] FIG. ~~13b~~ 13B is a graph showing a change ~~of the value of~~ in the area parameter b~~, in which the value of the area parameter b is decreased as~~ according to a change in the diastolic blood pressure. As the diastolic blood pressure becomes higher, a value of the area parameter b decreases.

[0089] As for the correlation of each parameter shown in ~~FIGs. 12 and 13~~ FIGS. 12A through 12D, as the systolic blood pressure ~~is increased~~ increases, the integral parameter a and the transition time ~~parameters a and~~ parameter c ~~result in a linear decrease~~ linearly decrease, and the area parameter b and the maximum amplitude ~~parameters b and~~ parameter d ~~result in a linear increase~~ linearly decrease.

[0090] ~~In~~ As for the correlation of each parameter shown in FIGS. 13A and 13B, as the diastolic blood pressure increases, the transition time parameter c and the area ~~parameters c and~~ parameter b ~~result in a linear decrease according to the blood pressure~~ linearly decrease.

[0091] Using the correlation between the systolic and diastolic blood ~~pressure~~ pressures and the ~~respective~~ parameters a, b, c and d, an aspect of the ~~present~~ invention ~~proposes an operation~~ uses a blood pressure determination algorithm as follows:

Maximum blood pressure (systolic blood pressure)

~~P= 919.121Ar+17.157Max-98.26Int + 161.736D_Dt~~

$$P = 919.121 \cdot Ar + 17.157 \cdot Max - 98.26 \cdot Int + 161.736 \cdot \Delta T$$

Minimum blood pressure (diastolic blood pressure)

~~P= 146.161-78.903 D_Dt-442.904 D_Ar~~

P = 146.161 - 78.903·ΔT - 442.904·Ar

where P ~~:~~ is pressure ~~(mmHg)~~ in mm Hg, ~~Dt and D_Dt : ΔT (sec), Ar and D_Ar : area, and Int : Integral~~ is the integral parameter a, Ar is the area parameter b, ΔT is the transition time parameter c in seconds, and Max is the maximum amplitude parameter d.

[0092] The maximum blood pressure refers to the systolic blood pressure. The formula for the maximum blood pressure is derived using the correlation between ~~each parameter~~ the four parameters and the systolic blood pressure. The minimum blood pressure refers to the diastolic blood pressure. The formula for the minimum blood pressure is derived using ~~relationship~~ the correlation between the diastolic blood ~~pressures according to changes of~~ pressure and the transition time parameter c and the area ~~parameters c and~~ parameter b.

[0093] Further, in the blood pressure determination algorithm, a series of constants by which the ~~respective~~ parameters a, b, c and d are multiplied refer to quantities by which the parameters a, b, c and d are varied according to the blood pressure, and represent a specific weight of each parameter according to the change of the blood pressure. That is, the constant is for statistically representing a change rate of the blood pressure as the parameters a, b, c and d are changed.

[0094] Therefore, the controlling section 70 ~~controls to apply~~ applies the ~~respective~~ parameters a, b, c and d ~~operated~~ determined in the foregoing ~~step~~ process to the ~~operation~~ blood pressure determination algorithm~~,~~ ~~and~~ to ~~operate~~ determine the maximum (systolic) blood pressure (block S28) and the minimum (diastolic) blood pressure (block S 29), and ~~to display~~ displays the ~~operated result~~ determined maximum and minimum blood pressures on the display 11 ~~(S28 and S29)~~ (block S18 in FIG. 9).

[0095] FIG. 14 is a graph ~~tabling accumulative~~ of a cumulative distribution of ~~expectation and observation~~ expected values versus a cumulative distribution of observed values for a blood pressure determination algorithm using the ~~forgoing each parameter~~ parameters described above and shown in FIG. 11.

[0096] As shown, the graph ~~takes~~ is a straight line when ~~two~~ the expected values are the same as the observed values. By observing how standardized residuals are distributed relative to an expected straight line, the two ~~distribution~~ distributions can be compared. The result is

that, because the standardized residuals are near a normal distribution, the blood pressure measurement using the automatic blood pressure measuring instrument and method according to an aspect of the ~~present~~ invention has a very high degree of prediction ~~degree~~.

[0097] The automatic blood pressure measuring instrument according to an aspect of the ~~present~~ invention using a pressure sensor such as a piezo sensor measures a blood pressure using correlation between a pulse wave signal and an ECG signal, and can be used to measure blood pressures of all persons, including infants, low blood pressure patients, and intensive care patients, because it makes use of various parameters ~~between~~ determined by comparing and analyzing the pulse wave signal and the ECG signal, such as a transition time parameter, an integral parameter, an area parameter and a maximum amplitude parameter.

[0098] Additionally, it is possible to measure a blood pressure without inserting a catheter into an artery. Thus, it is possible to prevent various disadvantages which ~~has~~ have attracted attention in an existing invasive blood measuring method, such as a circulatory problem, infection, a blood clot and so on, and to measure an accurate blood pressure with more ease and safety. Further, it is possible to change a concept on an existing uncomfortable and inaccurate blood pressure measurement. It is expected that a future-oriented and high-tech and multifunctional blood pressure measuring instrument will be distributed at an exponential speed, and that request for industrialization will be rapidly increased, and that due to the advent of brand-new multifunctional microwave hemadynamometer, technical application to a domestic medical instrument field will be much expanded.

[0099] ~~While~~ Although several embodiments of the invention ~~has~~ have been shown and described, ~~with reference to certain preferred embodiments thereof,~~ it ~~will~~ would be ~~understood~~ appreciated by those skilled in the art that ~~various~~ changes ~~in form and details~~ may be made ~~therein~~ in these embodiments without departing from the principles and spirit ~~and scope~~ of the invention, ~~as~~ the scope of which is defined ~~by~~ in the ~~appended~~ claims and their equivalents.